Core Strength Development Behaviour of Organic and Inorganic Binders with New and Reclaimed Foundry Sand

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Abstract

Foundries using organic binders like alkaline phenolic show interest in the use of inorganic binders like sodium silicate in core making and mould process. The cost of dumping waste sand from alkaline phenolic plants are more as they contain more toxic gases as compared to those of inorganic sodium silicate plants. Foundries are looking into saving cost by possibly using their already existing reclaimed sand from alkaline phenolic plant in new plants using sodium silicate. This research initiated to assist an alkaline phenolic foundry decision to use their already available reclaim sand in the new sodium silicate plant planned to build. A process for preparing foundry cores or moulds, sands and chemical resins used made available. The chemical binders consisted of inorganic binder of Alkaline phenolic and an organic binder of sodium silicates with their catalysts. Sand materials consisted of new silica sand and reclaimed sand from foundry alkaline phenolic moulding plant. Core prepared by mixing sand with each binder and allowing them to cure at room temperature. Alkaline phenolic at a 1, 5% binder addition to sand and 20% to binder of catalyst addition. For Sodium silicate testing completed at 3% binder addition to sand and 10% to binder of catalyst. The curing time of 1 hour, 4 hours and 24 hours. The results showed that alkaline phenolic developed higher bending strength with new silica sand with strength of up to 32 N/cm^2 than with reclaimed and 20:80 new to reclaimed sand mixture which only reach the bending strength of 15 N/cm^2. Alkaline phenolic developed higher Tensile strength of 25 N/cm^2 with reclaimed sand and 20:80 new to reclaimed sand with 20 N/cm^2 than with new sand reaching only five N/cm^2. In conclusion, new sand can develop strength with both alkaline phenolic and sodium silicate binders. It is difficult to develop strength with sodium silicate binder when using reclaimed sand. Based on this research it not recommended the use of Reclaimed sand from alkaline phenolic plant on the new sodium silicate plant.

Key words

Sodium silicate, Alkaline phenolic, Self-hardening/ no bake, Curing time, Core

1.0 Introduction

In foundry production system, the more we can reuse the sand the more cost effective is the process. Sand reclamation is very important as it reduces cost of production in the foundry, as new sand is expensive. Recycling foundry as much as possible also reduce the cost of dumping waste sand. This research focus on of effect of sand condition on bending strength and Tensile strength behaviour on self-setting sodium silicate sand binder system and alkaline phenolic sand binder system at different curing times. This research will assist the foundry to determine cost effectiveness of using their already available reclaimed sand from alkaline phenolic plant when starting new sodium silicate plant. Alkaline phenolic ester cured (organic) and sodium silicate (inorganic) system are the two chemical bonded sand systems focussed on this research

1.2 Objectives

To mix sand with alkaline phenolic and soidium silicate resin
To produce cores for bend strength testing and tensile strength testing using the mixed sand
To allow the cores to cure for different times

To test the bend and tensile strength of the cores at different curing times

2.0 Literature review

Proper selection of moulding and core sands is very important for the quality of the casting (Stachowicz, et al 2013). Factors such as the cost of moulding sand, mixing equipment, equipment for cleaning casting, disposing used mould and core sands (Stachowicz, et al 2013). The cost of new silica sand is high therefore ability to recover as much sand as possibly after casting is important in selection of casting process (Stachowicz et al 2013). Silica sand is widely used in foundry mould and core making processes because it is easily available, has lower cost of tooling, scope of metals is broad in silica sand and geometry parts has fewer limitations (Mhamane et al 2018). Sand reclamation allows the re-use of the sand after casting, making foundries buy less new sand and as a result, less sand is dumped reducing environmental impact as well as cost (Grabowska at al 2014). Chemical bonded sand systems for mould and core making classified into those that use inorganic binders and those using organic binders (Mhamane et al 2018).

Foundries mostly use organic binders for moulding and core making process due to their high durability, good dimensional accuracy and used sand easily regenerated (Kmita et al 2018). These organic binders are pollutant and not environmentally friendly making it expensive to dispose (Kmita et al 2018). Organic binders emit different crack components during casting process, the emitted product are hazardous to health and environment (Huang et al 2016). As a response to environmental regulations, foundries have been looking for other raw materials, which are more environmentally friendly than organic binders (Anwar et al 2022)No bake alkaline phenolic binders are widely used in mould and core making processes (Holtzer and Danko 2015). Alkaline phenolic used in almost all types of alloys (Holtzer and Danko 2015). Alkaline phenolic resins are used in the foundry moulds and cores due to their major influence of improving casting finish (Huang et al 2016)Organic binders are eco-friendly as compared to inorganic binders (Stachowicz, et al 2017). Moulding sand that used Sodium silicate binders have higher temperature strength than organic binders (Stachowicz, et al 2017).

The use of inorganic binders have been growing in metal casting industries for core making (Fortini 2021). Sodium silicates have good dimensional tolerance due to their high strength and high permeability producing gas hole-free casting (Parappagoudar et al 2011). Sodium silicate is an inorganic binder with low toxicity, low cost and cleanliness although they have low collapsibility and low strength of the mould (Huang et al 2016) High retained strength of these binders cause difficulty in breaking the moulds after shake out and may results on hot tear in castings (Parappagoudar et al 2011). However, inorganic binders have health and environmental benefits, technical improvements are required to address some inherent limitations of this technology (Fortini et at 2021). Sodium silicate binders are also eco-friendly and has low emission of harmful substances (Stachowicz et al 2013). Self-setting sodium silicate binder systems curing rate becomes slower than desired at low temperatures and can be faster than designed as temperature increases (La Fay 20120).

3.0 Method

Testing completed on Alkaline phenolic at a 1, 5% binder addition to sand and 20% to binder of catalyst addition. For Sodium silicate testing completed at 3% binder addition to sand and 10% to binder of catalyst. The moulding sand used in this research were prepared of new silica sand and reclaimed silica sand collected from alkaline phenolic moulding process. A portion of 4 kg sand per each mixture was prepared in the laboratory using blend mixer. After mixing, the core were prepared using a corebox and the samples were hand rammed. The core samples then cured at the laboratory at room temperatures and testing done after different curing times to determine strength behaviour (bending and tensile strength).

Bending strength specimen were prepared using a core box with standard specimen dimensions of 1” x 1” x 8” (22.4 mm x 22.4 mm x 172.5 mm). The tensile strength specimen were prepared using a core box with standard specimen dimensions of 1 x 1 inch (22,4 mm x 22,4 mm) central section tensile test specimen. The testing done using universal sand strength machine.

4.0 Results and Discussions

4.1 Graphic results

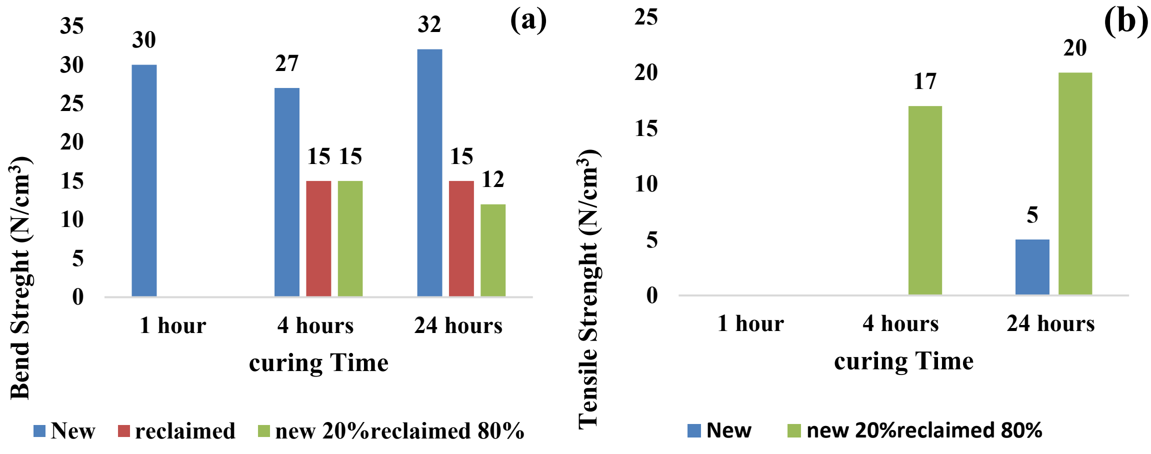

Figure 1(a) and (b) respectively displays the bending and tensile strength

Strength development at various sand ration using alkaline phenolic is shown in Figure 1. The figure compares the strength development for the various curring times (1 to 24 hours). Figure 1(a) and (b) respectively displays the bending and tensile strength. It was observed that the new sand appeared to develop strength more easily than the reclaim and the mix (20/80 new and reclaim (Figure 1(a)). After 1 hour its bend strength was evaluated at 30 which increase to 32 N/cm^2 after 24 hours of curing. While the two others had a nill value and increased to 15 and 12 N/cm^2 individually for reclaim and mix after 24 hours. On the other hand, the tensile strength showed the opposite trend. The new sand showed the lowest tensile strength value as opposed to the mixed sand and reclaimed which had the highest value.

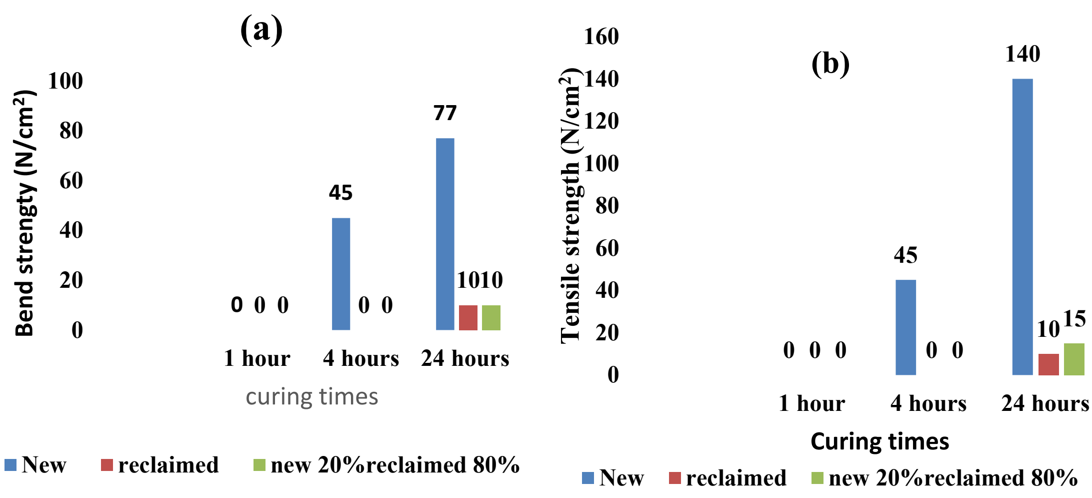

Figure 2 (a) and (b). Shows the bending strength development of sodium silicate binder

Sodium silicate strength development at various sand ratios is shown in figure 2. Strength development at various curing time using sodium silicate were compared in figure. Figure 2(a) and (b) respectively displays the bending and tensile strength. New strength seems to develop strength more easily than reclaimed sand and mixed sand (20/80 new and reclaimed sand (figure 2(a) and (b). After 4 hours both bend and tensile strength were evaluated at 45 N/cm^2 which increased to 77 N/cm^2 for bend strength and 140 N/cm^2 for tensile strengt for new sand. While the other sand remained at nill value for both bend and tensile strength, increased to 10 and 15 N/cm2 after 24 hours for reclaimed, and mix sand.

5.0 Conclusions

New silica sand can develop bending strength with both alkaline phenolic and sodium silicate binders. Higher bending strength reached with sodium silicates than alkaline phenolic when using new silica sand. Alkaline phenolic binder can develop strength with reclaimed sand and 20:80 new to reclaimed sand. It is difficult for sodium silicate to develop bending strength with reclaimed sand from alkaline phenolic plant. Sodium silicate can develop higher tensile strength with new sand than alkaline phenolic. Alkaline phenolic can develop tensile strength with reclaimed sand and 20:80 new to reclaimed sand whereas sodium silicate struggle to develop strength with reclaimed sand. It is not advisable to use reclaimed sand from alkaline phenolic plant in the sodium silicate plant. For future, more test with different new sand to reclaimed sand ratios should be tested to see how to reduce the use of new sand. The sodium silicate samples can be cured using CO_2 gas or using heat in the furnace to improve curing time.

6.0 Reference

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7.0 Biographies

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